

THE INVENTION CLAIMED IS

1. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant comprising a polymer composition consisting essentially of (i) a polysiloxane and (ii) a readily decomposable resin,

said polysiloxane being a reaction product between fine particles of silica and a hydrolyzate of at least one alkoxysilane represented by the following formula (I):



wherein X represents a hydrogen atom, a fluorine atom, an unfluorinated or fluorinated alkyl group of 1 to 8 carbon atoms, an aryl group or a vinyl group; R represents a hydrogen atom, an alkyl group of 1 to 8 carbon atoms, an aryl group or a vinyl group; and n is an integer of 0 to 3;

(b) heating the thus-coated film; and then

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

2. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 1, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

3. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein the polymer composition is an interpenetrated polymer composition in which the polysiloxane and the readily decomposable resin are entangled in each other on the molecular chain level;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

4. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein the fine particles of silica are obtained by hydrolyzing at least one alkoxysilane represented by the formula (I), optionally followed by aging;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

5. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein the polysiloxane is obtained by allowing a hydrolyzate of at least one alkoxysilane represented by the formula (I) to react with the surfaces of the fine particles of silica;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

6. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein the readily decomposable resin is a resin which is decomposed or vaporized by heating at a temperature

of not more than 500°C or by irradiating with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

7. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein the readily decomposable resin has a number-average molecular weight of 500 to 50,000 based on polystyrene;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

8. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein the polymer composition is obtained by performing a catalytic hydrolysis reaction of alkoxysilane in a solution comprising:

(i) the fine particles of silica having an average particle diameter of 5 to 50 nm;

(ii) at least one alkoxysilane represented by the above formula (I);
and

(iii) the readily decomposable resin dissolved in an organic solvent being insoluble in water,

with addition thereto of water and an acid catalyst or an aqueous solution containing the acid catalyst;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

9. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein a weight ratio (A/B) of the polysiloxane (A), in terms of SiO₂, to the readily decomposable resin (B), both being a constituent part of the polymer composition, is in the range of 95/5 to 50/50;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

10. A substrate coated with a silica-containing film with a low-dielectric constant, which is a low-density film formed by:

(a) applying onto a substrate the coating liquid for forming a silica-containing film with a low-dielectric constant according to claim 1, wherein a mixing ratio (A/B) by weight, in terms of SiO₂, of the fine particles of silica (A) to the alkoxysilane (B) represented by the formula (I), both being used for preparing the polysiloxane, is in the range of 1/99 to 10/90;

(b) heating the thus-coated film; and

(c) decomposing or vaporizing the readily decomposable resin contained in the film by a heat treatment at a temperature of not higher than 500°C or by irradiation with ultraviolet radiation, infrared radiation, electron beam, X-ray or oxygen plasma.

11. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 3, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

12. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 4, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

13. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 5, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

14. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 6, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

15. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 7, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

16. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 8, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

17. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 9, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.

18. The substrate coated with a silica-containing film with a low-dielectric constant as claimed in claim 10, wherein the average diameter of pores or voids present in the low-density silica film is not more than 5 nm.